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The EOSDIS Products Usability for Disaster Response

Durga N. Kafle[1,3] (durga.n.kafle@nasa.gov), Lalit Wanchoo[1,3] (lalit.wanchoo@nasa.gov), Young-In Won[2,3] (youngin.won@nasa.gov), and Karen Michael[3] (karen.michael@nasa.gov)

[1] ADNET Systems, Inc., 7515 Mission Drive, Suite A100, Lanham, MD 20706 , [2] KBRwyle,7515 Mission Drive, Lanham, MD 20706, [3]Earth Science Data and Information System Project (Code 423), NASA Goddard Space Flight Center, Greenbelt, MD 20771

Introduction

The Earth Observing System (EOS) Data and Information System (EOSDIS) is a key core capability in NASA's Earth Science Data System program. The EOSDIS science operations are performed within a distributed system of interconnected nodes: the Science Investigator-led Processing Systems (SIPS) and the distributed, discipline-specific, Earth science Distributed Active Archive Centers (DAACs), which have specific responsibilities for the production, archiving, and distribution of Earth science data products. NASA has also established the Land, Atmosphere Near real-time Capability for EOS (LANCE) program, which produces and distributes near real-time (NRT) products within a latency of no more than 3 hours. These data products, including NRT, have been widely used by scientists and researchers for studying Earth science, climate change, natural variability, and enhanced climate predictions including disaster assessments. The National Science and Technology Council's Subcommittee on Disaster Reduction (SDR) has defined 14 major types of disasters (see Table 1) such as floods, hurricanes, earthquakes, volcanos, tsunamis, etc. The focus of this study is to categorize both NRT and standard data products based on their applicability to the SDR-defined disaster types and to demonstrate the usage of such products for the study of various disasters that have occurred over the last 5 to 7 years. Analysis of the distribution metrics provides an indication of the product usage for studying such disasters. The distribution metrics analyzed include data volume, number of data files, number of users, user domains, user country, etc.

Table 1. Categorization of Selected in-orbit Missions/Instruments for Various Disasters Applications

Disaster (s)	AQUA	AURA	CALIPSO	GCOM-W1	GPM	GRACE	SENTINEL-1A	SUOMI NPP	TERRA
Floods (Overflow or inundation from a river or other body of water and causes or threatens damage)	AIRS			AMSR2	DPR	GRACE	SAR	ATMS	ASTER
	MODIS							VIIRS	MISR
									MODIS
Drought (Persistent and abnormal moisture deficiency that has adverse effects on vegetation, animals, or people)	CERES	OMI		AMSR2	DPR	GRACE		CERES	ASTER
	MODIS				GMI			VIIRS	CERES
	AIRS								MISR
									MODIS
Earthquake (Shaking and vibration at the surface of the earth resulting from underground movement)	MODIS						SAR	VIIRS	ASTER
	MODIS	OMI		AMSR2	GMI			VIIRS	MISR
Hurricanes (Develop when a tropical storm intensifies and winds reach 74 miles per hour)	AIRS				DPR			ATMS	MODIS
									ASTER
Landslides and Debris Flow (Gravity driven ground movement, which can occur in offshore, coastal and onshore environments)	MODIS			AMSR2	GMI		SAR	ATMS	ASTER
								VIIRS	MODIS
Volcano (Vent at the earth's surface through which magma and/or associated gases erupt spreads out of control)	MODIS	OMI	CALIOP				SAR	VIIRS	MISR
	AIRS	MLS						OMPS	ASTER
		TES							MODIS
Wildfires (Aging conflagration that rapidly spreads out of control)	MODIS	TES	CALIOP			GRACE	SAR	VIIRS	MODIS
	AIRS	OMI						OMPS	ASTER
									MOPITT
Winter storm (Heavy snow and rain, freezing rain, strong winds, and cold temperatures)	MODIS			AMSR2					MODIS
	AIRS								ASTER
Dust storm (A strong, turbulent wind that carries clouds of the fine dust, soil, and sand over a large area)	MODIS	OMI	CALIOP					OMPS	MODIS
	AIRS							VIIRS	ASTER
Heatwave (Prolonged period of warm season temperatures well above normal for the area, often accompanied by high humidity)	MODIS	MLS		AMSR2				VIIRS	MODIS
Tornado (Violently rotating column of air extending from a thunderstorm to the ground)	MODIS	OMI			GMI			VIIRS	MISR
	AIRS				DPR				MODIS
									ASTER
Human and Ecosystem Health (Conditions that predispose a person to adverse health outcomes or result in the deterioration of ecosystem structure and functioning)	MODIS						SAR	VIIRS	MODIS
	AIRS								ASTER
									MOPITT
Technological Disasters (Release of hazardous substances that impact human health and safety, the environment, and/or the local economy)		OMI	CALIOP				SAR	OMPS	MOPITT
		TES							
Tsunami (Large rapidly moving ocean waves resulting from disturbances on the ocean flow)	MODIS				GMI			VIIRS	MODIS
					DPR				MISR
									ASTER

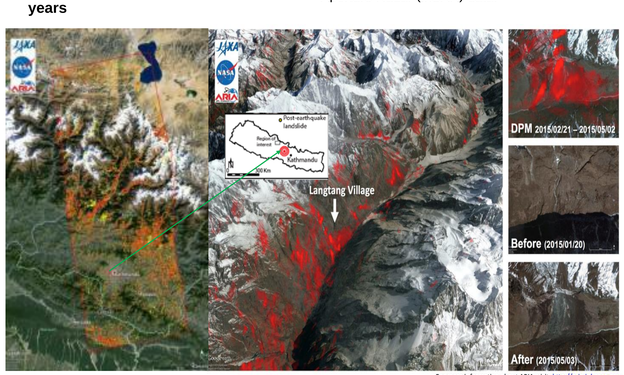
Distribution Metrics for Selected Disasters

Illustrations of Five disasters:

1. 2015 Nepal Earthquake
2. April 2010 Gulf of Mexico Oil Spill
3. 2010 Iceland and Western Europe Volcanic eruption
4. October, 2016 Haiti Hurricane Mathew
5. Fires and other disasters over last 3 years

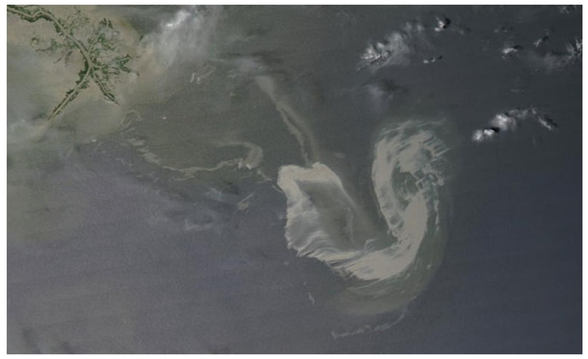
1. 2015 Nepal Earthquake

Multiple data products from different instruments were downloaded by users for studying 2015 Nepal earthquake. The image below shows the Damage Proxy Map (DPM) that helped identify the hardest hit areas during the earthquake, covering the city of Kathmandu and the Langtang region (70x180 kilometers) using L-band interferometric Synthetic Aperture Radar (InSAR) data.



The highlighted areas of potential damage caused by the M7.8 Nepal earthquake derived from L-band Interferometeric Synthetic Aperture Radar (InSAR) data. The images on the right side show how the red regions in the DPM correlate with landslide debris, as shown by the dark surface in the image marked as "After" *(https://www.nasa.gov/jpl/new-alos-2-damage-map-assists-2015-gorkha-nepal-disaster-response).*

2. April, 2010 Gulf of Mexico Oil Spill



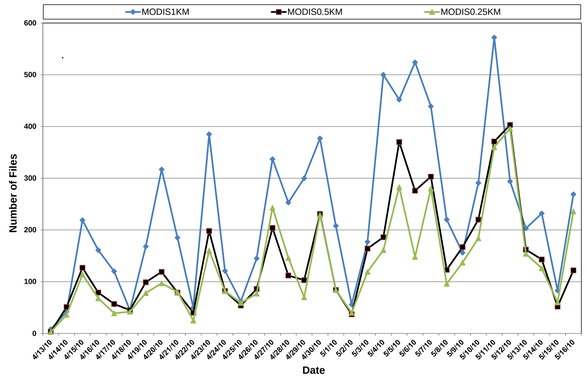
The image taken by MODIS instrument aboard NASA's Aqua satellite. This image shows the Gulf of Mexico oil spill that began with the explosion of an offshore drilling rig on April 20, 2010. The oil-slicked water appears brighter due to the oil's greater reflectance *(https://www.nasa.gov/topics/earth/features/oil_spill_initial_feature.html)*

3. 2010 Iceland and Western Europe Volcanic Eruption

The visible ash plume from Iceland's Eyjafjallajökull volcano captured by NASA's Aqua satellite on April 17, 2010. The ash caused the shutdown of air traffic over much of Europe for several days *(https://www.nasa.gov/topics/earth/features/ash_plume.html).*

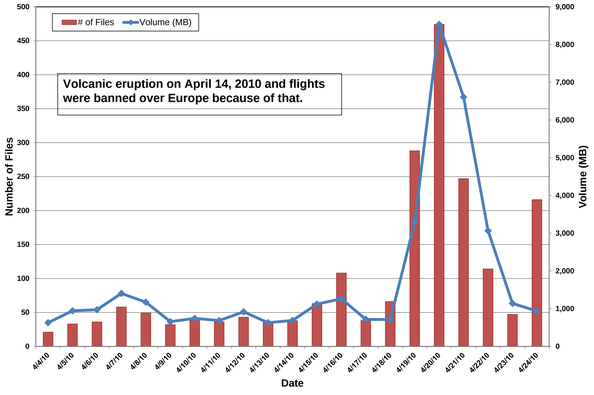
Distribution Metrics (continued)

Distribution of MODIS (Aqua and Terra) Level 1B Near real-Time (NRT) Products by LANCE MODAPS for Oil Spill in Gulf of Mexico, 2010



The above figure shows the increased usage of MODIS L1B near real-time products for studying oil spills in the Gulf of Mexico in 2010 over a month. The highest usage of such products was on May 11, 2010, about twenty days after the oil spills.

Distribution of OMI L2 SO2 Products (OMSO2/OMSO2G) Volcanic Eruption in Europe in 2010 (over Iceland, British Isles and Western Europe)

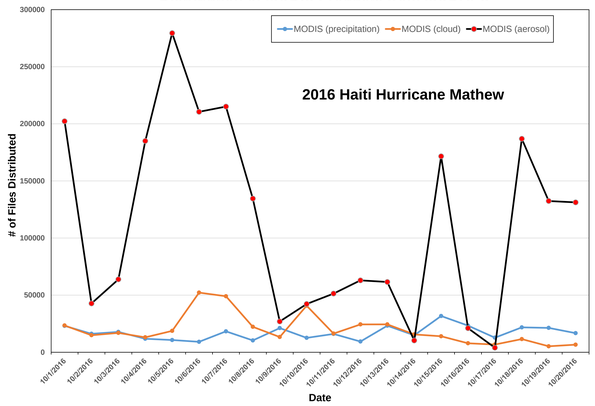


The highest data usage was observed on 4/20/2010, three days after the volcanic eruption, indicating the significant usage of the Ozone Monitoring Instrument (OMI) SO_2 product for studying volcanic eruptions.

4. October, 2016 Haiti Hurricane Mathew

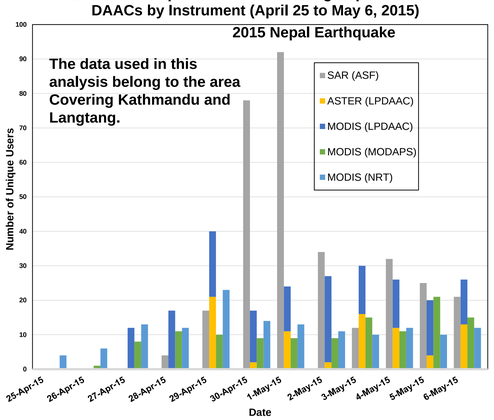
On October 4, 2016, Hurricane Matthew landfall on southwestern Haiti as a Category 4 storm, the strongest storm (~230 km/hour) to hit the Caribbean nation in more than 50 years. The MODIS on NASA's Terra satellite acquired this natural-color image *(https://www.nasa.gov/image-feature/hurricane-matthew-hits-haiti).*

Distribution of MODIS Products from MODAPS



This figure shows the largest data usage of the MODIS Level 2 data products on 10/5/2016, a day after the Hurricane Matthew hit southwestern Haiti. In addition, a similar higher usage of the same products was observed on 10/15/2016 and 10/18/2016. This indicates studying of aerosol-cloud interaction and its impact on hurricanes.

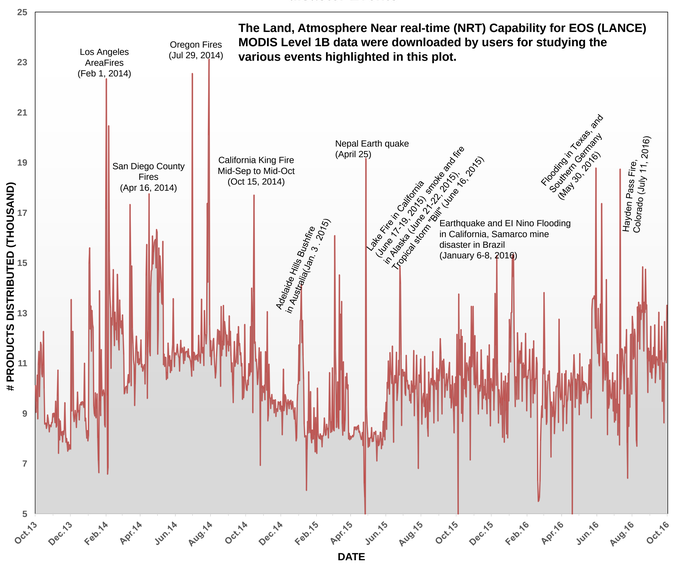
Number of Unique Users Downloading Nepal Data from DAACs by Instrument (April 25 to May 6, 2015)



The number of unique users downloading multiple data products from Synthetic Aperture Radar (SAR), Advanced Spaceborne Thermal Emission and Reflectance Radiometer (ASTER) and Moderate Resolution Imaging Spectroradiometer (MODIS) instruments after the earthquake. This figure shows an increase in the number of users downloading data after the earthquake, specifically the two large peaks on 4/30/15 and 5/1/15 corresponding to SAR data usage.

5. Fires and Other Disasters over Last 3 Years

FY14-FY16 MODIS Aqua and Terra data distribution by LANCE MODAPS during Various disaster Events



Summary and Conclusions

- **This analysis depicts the usage of data products that are categorized for studying various disasters.**
- **This categorization is helpful in identifying the products applicable for studying various hazards.**
- **This data usage analysis information will also be helpful for data centers to develop the functionality and allocate the resources needed for enhanced access and timely availability of the data products that are critical for time-sensitive analyses.**

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